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SHIMIZU LABORATORY (June 1957~)

Head: Dr. Sakae Shimizu

Professor S. Shimizu now directing this Section joined the Institute in July 1952. From this time till 1956, he worked hard to conduct a big project of reconstruction of our Kyoto cyclotron in cooperation with Professor K. Kimura, head of the project. Our cyclotron—15 MeV deuteron acceleration—was completed with success in spring of 1956. During this period he worked also as a leader of a group of workers who studied on many aspects of the radioactive fallout from the nuclear explosion test at Bikini Atoll on March 1, 1954. Many interesting results and information obtained by this temporary research project were compiled by him as a monograph entitled "The Radioactive Dust from the Nuclear Detonation" and published from the Institute as a supplementary issue of the Bulletin of the Institute for Chemical Research, Kyoto University, in November 1954.

After the completion of the cyclotron he worked to ignite the university research reactor project of the University. In order to get valuable information and knowledge on research reactors and experimental nuclear physics of his interest he visited the United States and western European countries for about seven months in 1956. For a few years thereafter he worked to promote the research reactor project and to strengthen a new department, Department of Nuclear Engineering.

In March 1957 he transferred from the cyclotron laboratory to the Radioisotope Research Laboratory of the University as its supervisor. In June in the same year the Shimizu Laboratory was established, and he could start his own research plan, but from nothing. For the first stage of his own laboratory he had to work in the old wooden building in the campus of the University Hospital with few research members. However, in July 1960 a new building of the Radioisotope Research Laboratory in the north campus of the University was achieved, where he could have his laboratories and commenced his research activities according to his own philosophy. For the past several years, since he had have research laboratories and several research fellows in the new building, activities of the Shimizu Laboratory have been developed year by year. In addition to his responsibility for operation of the Radioisotope Research Laboratory, in his Laboratory some of interesting researches in the field of experimental nuclear physics have been preformed. The main problems so far studied are as follows:

I. Gamma-Ray Irradiation Facility

In 1957 a 2000 Ci ^{60}Co gamma-ray irradiation facility with particular features was constructed as a first multi-curie facility in this country. Results of studies in many fields by the use of this facility have been published every year in the special issues of our Bulletin entitled "Physical, Chemical and Biological Effects of Gamma Radiation".

II. Nuclear Spectroscopy

By the use of a Siegbahn-Slätis type intermediate-image spectrometer, multi-channel pulse-height analyzers and elaborated electronic apparatuses some experimental studies using radioactive nuclei have been performed. One of the problems we studied was the mono-energetic positron emission of the 1409 keV E1 transition in ^{152}Sm . The branching ratio for this transition has been determined as $(2.5 \pm 1.0) \times 10^{-7}$ positron per gamma transition and the mean life of the 1531 keV level of ^{152}Sm has been estimated to be $\tau = 5.7 \times 10^{-15}$ sec.

III. Nuclear Phenomena involving Shell Electrons

For the past four years, main efforts of the Laboratory have been concentrated to the following three works.

a) Incoherent scattering of gamma rays by K-shell electrons.

When the atomic binding energy of the struck electron is not negligible compared to the kinetic energy which this electron is to acquire as a Compton recoil electron, the differential cross section of the scattering is expected to deviate from that predicted by the Klein-Nishina formula. The differential cross section for the incoherent scattering of 662-keV gamma rays by the K-shell electrons of $_{50}\text{Sn}$, $_{73}\text{Ta}$ and $_{82}\text{Pb}$ was determined by experiment. The experimental results at scattering angles 20° , 35° , 50° , 65° and 100° with these scatterer elements the cross section ratio $d\sigma_R/d\sigma_F$ is less than unity for smaller scattering angles and approaches zero as the angle decreases to zero, as predicted by nonrelativistic calculation. For large angles, this ratio is greater than unity and at 100° it is found to be equal to about 1.2 for $_{50}\text{Sn}$, 1.3 for $_{73}\text{Ta}$, and 1.5 for $_{82}\text{Pb}$.

b) Search for radiationless annihilation of positrons.

As a competitive process of the single-quantum annihilation of positrons the radiationless annihilation would be expected. This process is interpreted as: when the single-quantum annihilation arises with one of the K- or L-shell electrons, owing to the presence of other bound electrons in the atom involved it is possible for the excess energy liberated in such a radiative transition to be used to eject another bound electron from the atom, the annihilation thus taking place without radiation. As an incident mono-energetic positron beam we used a 300 keV beam obtained by a Siegbahn-Slätis type spectrometer with about a 12 mCi ^{22}Na source. We have found the cross section for radiationless annihilation of 300 keV positrons in lead to be $(3.0 \pm 0.9) \times 10^{-26}$ cm², as a sum of those for KK, KL, KM and LL pairs of bound electrons, and found also the ratio of the number of radiationless annihilations to that of the two-quantum annihilations to be about $1:6.8 \times 10^4$.

c) Effect of chemical state on the decay constant of $^{235\text{m}}\text{U}$.

Experimental investigation of the influence of chemical forms on the decay constant of $^{235\text{m}}\text{U}$ has been performed. Applying the differential method with two identical, specially designed secondary electron multipliers, emission rates of the internal-conversion electrons of very weak energy from the isomer in different chemical states have been compared. We used metallic uranium (U) and uranium atoms

slightly diffused into carbon (UC) or silicon (USi) base for the different chemical states. The results are: $\lambda(\text{U}) - \lambda(\text{UC}) = (3.18 \pm 0.50) \times 10^{-3} \lambda(\text{U})$, $\lambda(\text{U}) - \lambda(\text{USi}) = (2.21 \pm 0.36) \times 10^{-3} \lambda(\text{U})$, and $\lambda(\text{USi}) - \lambda(\text{UC}) = (0.97 \pm 0.43) \times 10^{-3} \lambda(\text{USi})$. Errors are standard deviations. We also determined the half-life of $^{235\text{m}}\text{U}$ to be $T_{1/2} = 26.05 \pm 0.05$ min and the transition energy of this isomeric state to be 30 ± 3 eV.

IV. Mössbauer Effect Studies

The Mössbauer effect was applied to study the magnetic and spin-relaxation properties of ultrafine particles of $\alpha\text{-Fe}_2\text{O}_3$ at 120° to 300°K using the Mössbauer spectrometer built in the Laboratory. The modified apparatus using an electro-mechanical transducer has recently been constructed and now in use for the study on some nuclear phenomena.

V. Semiconductor Radiation Detectors

The surface barrier type silicon detector and Li-drifted silicon junction detector were manufactured successfully by ourselves two years ago and are now being used for our experimental purposes. We have recently started to investigate the preparation procedure of Li-drifted germanium detectors with excellent energy resolution for gamma-ray measurements.

Publications

(* indicates an article published in Japanese)

I. Gamma Rays and Gamma-Ray Irradiation

1. S. Shimizu, T. Hanai and S. Okamoto: The Absorption of γ -Rays from Co^{60} in Several Elements, *Bull. Inst. Chem. Res., Kyoto Univ.*, **25**, 53 (1951).
2. S. Shimizu, T. Hanai and S. Okamoto: The Absorption of Gamma-Rays from Co^{60} in Several Elements. (II), *Bull. Inst. Chem. Res., Kyoto Univ.*, **26**, 64 (1951).
3. S. Shimizu, T. Hanai, and S. Okamoto: The Absorption of Gamma-Rays from Co^{60} , *Phys. Rev.*, **85**, 290 (1952).
4. S. Okamoto, Y. Nakayama and K. Takahashi: Two Kilocurie Cobalt-60 Gamma-Ray Irradiation Facility, *Bull. Inst. Chem. Res., Kyoto Univ.*, **37**, 299 (1959).
5. S. Shimizu, S. Tanaka and Y. Nakayama: Gamma-Ray Dosimetry in an Irradiation Cavity of the 2000 Curie Cobalt-60 Facility, *Bull. Inst. Chem. Res., Kyoto Univ.*, **37**, 306 (1959).
6. T. Saigusa, S. Horikiri, M. Kondo and S. Shimizu: A Cobalt-60 Irradiation Facility for Radiation Chemistry, *Bull. Inst. Chem. Res., Kyoto Univ.*, **39**, 166 (1961).
7. T. Hyodo and S. Shimizu: Some Experiments on Gamma-Ray Backscattering, *Bull. Inst. Chem. Res., Kyoto Univ.*, **39**, 180 (1961).
8. T. Nakakado and T. Saigusa: The Effects of Gamma Radiation on Electric Characteristics of the Electronic Circuit Components. (I), *Bull. Inst. Chem. Res., Kyoto Univ.*, **40**, 67 (1962).
9. M. Endo, M. Kondo and T. Saigusa: A Versatile Cobalt-60 Irradiation Facility, *Bull. Inst. Chem. Res., Kyoto Univ.*, **41**, 89 (1963).
10. H. Kakimoto, T. Saigusa and S. Shimizu: Streaming of Gamma Rays through Metallic Pipes, *Bull. Inst. Chem. Res., Kyoto Univ.*, **43**, 22 (1965).
11. S. Horikiri and T. Saigusa: The Study of Energy Transfer in Binary Organic Liquid Mixtures under Gamma-Irradiation, *Bull. Inst. Chem. Res., Kyoto Univ.*, **43**, 45 (1965).

II. Nuclear Spectroscopy

1. T. Mukoyama and S. Shimizu: Scintillation Spectroscopy Measurements of Gamma-Ray

- Energies from the Source of $\text{Eu}^{152,154}$, *Bull. Inst. Chem. Res., Kyoto Univ.*, **40**, 54 (1962).
2. T. Mukoyama, F. Makino and S. Shimizu: Gamma-Gamma Directional Correlations of Some Gamma-Ray Cascades in ^{110}Cd , *Bull. Inst. Chem. Res., Kyoto Univ.*, **40**, 307 (1962).
 3. S. Shimizu and Y. Nakayama: Internal Conversion of the 1119 keV Transition in ^{65}Cu , *Nuclear Physics*, **31**, 600 (1962).
 4. Y. Nakayama and H. Hirata: Internal Conversion of the 1277 keV Transition in ^{22}Ne , *Nuclear Physics*, **40**, 396 (1963).
 5. R. Shibata and R. Katano: Measurements of Gamma-Ray Energies from Eu^{152} by the Scintillation Spectroscopy, *Bull. Inst. Chem. Res., Kyoto Univ.*, **42**, 42 (1964).
 6. S. Shimizu, Y. Nakayama, H. Hirata and H. Mazaki: Mono-Energetic Positron Emission in the Decay of ^{152}Eu , *Nuclear Physics*, **54**, 265 (1964).

III. Nuclear Phenomena involving Shell Electrons

1. S. Shimizu and H. Mazaki: The Effect of Chemical State on the Decay Constant of a Nuclear Isomer, $^{235\text{m}}\text{U}$, *Physics Letters*, **17**, 275 (1965).
2. S. Shimizu, T. Mukoyama and Y. Nakayama: Search for Radiationless Annihilation of Positrons, *Physics Letters*, **17**, 295 (1965).
3. S. Shimizu, Y. Nakayama, and T. Mukoyama: Incoherent Scattering of Gamma Rays by K-Shell Electrons, *Phys. Rev.*, **140**, A806 (1965).
4. H. Mazaki and S. Shimizu: Effect of Chemical State on the Decay Constant of $\text{U}^{235\text{m}}$, *Phys. Rev.*, **148**, 1161 (1966).
5. H. Mazaki and S. Shimizu: The Transition Energy of $^{235}\text{U}^{\text{m}}$, *Physics Letters*, **23**, 137 (1966).
6. H. Mazaki and S. Shimizu: Determination of Very Low Transition Energy of $^{235\text{m}}\text{U}$, *Bull. Inst. Chem. Res., Kyoto Univ.*, **44**, 394 (1966).

IV. Mössbauer Effect

1. T. Nakamura and S. Shimizu: Experimental Study on the Mössbauer Effect of ^{57}Fe in Several Iron Compounds, *Bull. Inst. Chem. Res., Kyoto Univ.*, **42**, 299 (1964).
2. R. Katano: Mössbauer Spectrometer using an Electromechanical Transducer in Conjunction with a Multichannel Pulse-Height Analyzer, *Bull. Inst. Chem. Res., Kyoto Univ.*, **44**, 386 (1966).

V. Radiation Detectors, Nuclear Instruments and Methods

1. S. Shimizu, H. Takekoshi and E. Nishimura: On the Scintillation Counter, *Bull. Inst. Chem. Res., Kyoto Univ.*, **25**, 54 (1951).
2. H. Takekoshi, K. Tsuruoka and S. Shimizu: The Construction of a Mass Spectrometer without the Use of Magnetic Field, *Bull. Inst. Chem. Res., Kyoto Univ.*, **27**, 52 (1951).
3. S. Shimizu and S. Okamoto: The Design of a New High Speed Scaling Circuit, *Bull. Inst. Chem. Res., Kyoto Univ.*, **27**, 54 (1951).
4. S. Shimizu, H. Takekoshi and E. Takekoshi: Efficiency of a Liquid Scintillation Counter, *Bull. Inst. Chem. Res., Kyoto Univ.*, **31**, 41 (1953).
5. S. Shimizu, A. Katase, H. Takekoshi and K. Takumi: On the Short-Circuiting Condensers in Kyoto Cyclotron, *Bull. Inst. Chem. Res., Kyoto Univ.*, **32**, 214 (1954).
6. T. Hyodo and S. Shimizu: A Note on the Effect of the Absorber Position in the Measurement of Beta-Ray Absorption, *Bull. Inst. Chem. Res., Kyoto Univ.*, **32**, 194 (1954).
7. S. Shimizu, F. Hirayama and S. Okamoto: Studies on Polystyrene Scintillators, *Annual Report of the Radioactive Isotopes in Japan*, **3**, 48 (1956).
8. M. Ise and Y. Nakayama: A Transistorized Dekatron Scaler, *Bull. Inst. Chem. Res., Kyoto Univ.*, **37**, 277 (1959).
9. K. Kimura, Y. Uemura, M. Sonoda, S. Shimizu, T. Yanabu, R. Ishiwari, J. Kokame, A. Katase, I. Kumabe, S. Yamashita, H. Takekoshi, K. Miyake, H. Ikegami and H. Fujita: A 105 cm Fixed Frequency Cyclotron of Kyoto University, *Bull. Inst. Chem. Res., Kyoto Univ.*, **39**, 368 (1961).
10. S. Nishii, T. Nakakado, Y. Nakayama and S. Shimizu: Lithium-Drifted Silicon Junction Detectors, *Bull. Inst. Chem. Res., Kyoto Univ.*, **42**, 319 (1964).

11. S. Nishiu: Response of a Large Sensitive Volume Lithium-Drifted Silicon Detector to Gamma and Beta Rays, *Bull. Inst. Chem. Res., Kyoto Univ.*, **44**, 74 (1966).

VI. Radioactive Fallout

1. S. Shimizu, H. Akagi, H. Goto, S. Okamoto, T. Ishida and Y. Kawai: Survey on the Radioactive Contamination of the No. 5 Fukuryu Maru, *Bull. Inst. Chem. Res., Kyoto Univ., Suppl. Issue*, p. 1 (Nov. 1954).
2. M. Ishibashi, T. Shigematsu, T. Ishida, S. Okada, T. Nishi, H. Takahashi, C. Matsumoto, S. Shimizu, T. Hyodo, F. Hiyama and S. Okamoto: Radiochemical Analysis of the Bikini Ashes, *Bull. Inst. Chem. Res., Kyoto Univ., Suppl. Issue*, p. 39 (Nov. 1954).
3. S. Shimizu and T. Hyodo: Rate of Decay of the Bikini Ashes, *Research in the Effects and Influences of the Nuclear Bomb Test Explosions, Japan Soc. for the Promotion of Science*, p. 471 (1956).

VII. Miscellaneous

1. S. Shimizu, H. Nakamura and I. Kumabe: On the Backscattering of β -Rays from C^{14} and P^{32} , *Bull. Inst. Chem. Res., Kyoto Univ.*, **26**, 65 (1951).
2. T. Naiki, T. Hanai and S. Shimizu: Measurement of Viscosity of Liquid Air, *Bull. Inst. Chem. Res., Kyoto Univ.*, **31**, 56 (1953).
3. I. Kumabe and S. Shimizu: The Backscattering of Beta-Rays, *Bull. Inst. Chem. Res., Kyoto Univ.*, **32**, 183 (1954).
4. T. Hamaguchi: Theoretical Studies on the Self Stability and Internal Feedbacks Transfer Functions of Boiling Water Reactor, *Bull. Inst. Chem. Res., Kyoto Univ.*, **40**, 92 (1962).

VIII. Reviews

1. S. Shimizu and R. Ishiwari: Measurements of Radioactivity, *Kagaku No Ryoiki, Suppl.*, **17**, 33 (1957).*
2. S. Shimizu: Scientific Background of Peaceful Applications of Nuclear Energy, (Japan United Nations' Association, Kyoto Branch, Kyoto, 1957).*
3. S. Shimizu: Effect of Chemical Binding on the Radioactive Decay Constant, *Kagaku To Kogyo (Tokyo)*, **18**, 935 (1965).*